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bi-monthly research notes

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FOREST PRODUCTS TECHNOLOGY

Effect of Preservative Treatments on Moisture Uptake by Field-test Stakes.—Before any chemical can be accepted as a new wood preservative, evidence must be provided that wood treated with it, and tested under natural conditions, can withstand fungal and insect attack. The most frequent field-test condition used for this purpose is the stake test (Am. Wood Preserv. Assoc. Stand. M7-69, 1965), in which small pieces of wood (frequently 100% sapwood) are buried to half their length in the ground. Because of the obvious importance of this test, and since the final preservative retentions specified in the commodity standards are frequently based on data from it, an understanding of the factors influencing the rate of decay of the treated stakes is of critical importance.

One of the most important factors in determining whether wood will decay is its moisture content. Without sufficient moisture, wood will not decay, and it has also been shown previously (Morton and Eggins, Mater. u. Org. 11:279-294, 1976) that the moisture content affects the surface growth and penetration of fungi in treated wood.

The object of this study was to examine the effect of the type of preservative on the uptake of moisture by treated stakes after 12 mo of field testing.

Kiln-dried ponderosa pine (*Pinus ponderosa* Laws.) sapwood stakes free from defects and of dimensions 2.0 x 4.5 x 45 cm were impregnated with pentacholorphenol (PCP), chromated copper arsenate (CCA-B and CCA-C), and ammoniacal copper arsenate (ACA) by a full-cell process (initial vacuum 55 cm Hg, 10 min; pressure 830 kPa, 2 h). All the stakes were completely penetrated with preservative to retentions of 3.2-9.6 kg/m^3 (0.2-0.6 lb/ft^3).

The stakes were then air-dried in the laboratory for 1 mo prior to installation at the graveyard-test area near Agassiz, B.C., in August 1975. They were buried in the ground to a depth of 22 cm. After 12 mo exposure, the stakes were removed from the ground, carefully cleaned, and immediately weighed. They were then returned to the laboratory for testing.

TABLE 1
Moisture-content data for treated stakes

Chemical	Top section* MC %	Top section* Standard deviation %	Bottom section* MC %	Bottom section* Standard deviation %	Average of two sections MC %
PCP	51	10	63	11	57
CCA-B	63	8	63	7	63
CCA-C	56	10	56	10	56
ACA	64	17	64	17	64

*Mean value of 12 stakes.

A labelled section approximately 2.5 cm in length was cut from both ends of each stake and weighed, and the moisture content was determined by standard procedures. For the waterborne-treated material, this amounted to oven-drying the stake sections, while for the PCP-treated sections it was necessary to perform toluene extractions by the procedure described in the American Wood Preservers Association Standard A6-76 (1976). A correction was applied to allow for loss of moisture between the stake weight as it was at the time of removal and at the time the stake was sectioned and dried.

The average monthly temperature followed the anticipated pattern for the lower mainland of British Columbia; the maximum monthly rainfall of almost 44 cm occurred during December. In the month prior to the removal of the stakes for observation, the rainfall recorded was 14.5 cm.

The mean moisture contents for each group of preservative-treated stakes are shown in Table 1. It is immediately obvious that, while the moisture contents of the top and bottom sections are identical for all of the waterborne-treated stakes, the top portions of the PCP-treated stakes were drier than the bottom sections. All the moisture contents are well in excess of the 22% usually considered as a minimum for the attack on wood by wood-destroying fungi.

Consider first the data for the top sections. The average moisture content of the PCP-treated stakes is significantly less than the average moisture contents of the ACA and CCA-B stakes ($F_{obs} = 3.69$, $F_{tab} = 2.83$ at the 5% level of significance). Indeed, in view of the natural partitioning of the treatments, the moisture content for the PCP oilborne treatment is significantly less than that for the waterborne salt treatments ($F_{obs} = 7.12$ approaches that required for the 1% level of significance). Thus the presence of the oil solvent appears to have retarded moisture uptake by the top-exposed portion of the stake. The higher moisture level for the CCA-B stakes compared with those impregnated with the CCA-C is most likely associated with the use of salts in its formulation (i.e. copper sulphate, sodium dichromate, and sodium arsenate), whereas the CCA-C preservative was composed of chemicals in their oxide form. Thus, after interaction in the wood, there are no salt byproducts (e.g. sodium sulphate) in the CCA-C treated wood as there would be with the CCA-B treated stakes. It should be noted, however, that when this difference between the moisture contents for the CCA-B and CCA-C treated stake tops was tested for significance, the F value failed to attain the value required even for the 5% level of significance.

The sections of the stakes that were buried in the ground exhibit a different pattern. The average moisture content of the PCP stakes was equal to the average moisture contents of the ACA and CCA-B stakes, and that of the CCA-C treated appeared to be slightly less than the rest, although this difference was not significant when tested statistically ($F_{obs} = <1$, $F_{tab} = 4.06$ at the 5% level of significance). Thus the presence of oil in the PCP stakes does not prevent the longitudinal movement of moisture up the stake due to the water in the soil.

During field testing, the moisture content in the buried portion of a treated-graveyard stake is not influenced by the type of preservative used. The use of an oilborne preservative causes only a slight lowering of the moisture content of the exposed portion of a stake. This would suggest that moisture content could be ignored in considering the factors affecting the *relative* performance of preservatives in a stake test at any given site. It would, however, be desirable to confirm this with a similar study made in a dry-climate area.—J.N.R. Ruddick, Forintek Canada Corp., Western Forest Products Laboratory, Vancouver, B.C.

GENETICS AND TREE IMPROVEMENT

Disk Electrophoretic Studies of Proteins and Isoenzymes in White Spruce (*Picea glauca* [Moench] Voss) Seeds.—White spruce is a variable species with a large transcontinental range in North America. So far, the genetic analysis of this species has been based largely on morphological and physiological methods applied to provenance trials in the greenhouse, the nursery, and the field (Nienstaedt and Teich, USDA Forest Serv. Res. Pap. WO-15, 1972). Such studies are now supplemented in many species by analyses of proteins and enzymes. These analyses allow more detailed studies without the need to raise seedlings. Isoenzymes, in particular, are being studied to identify

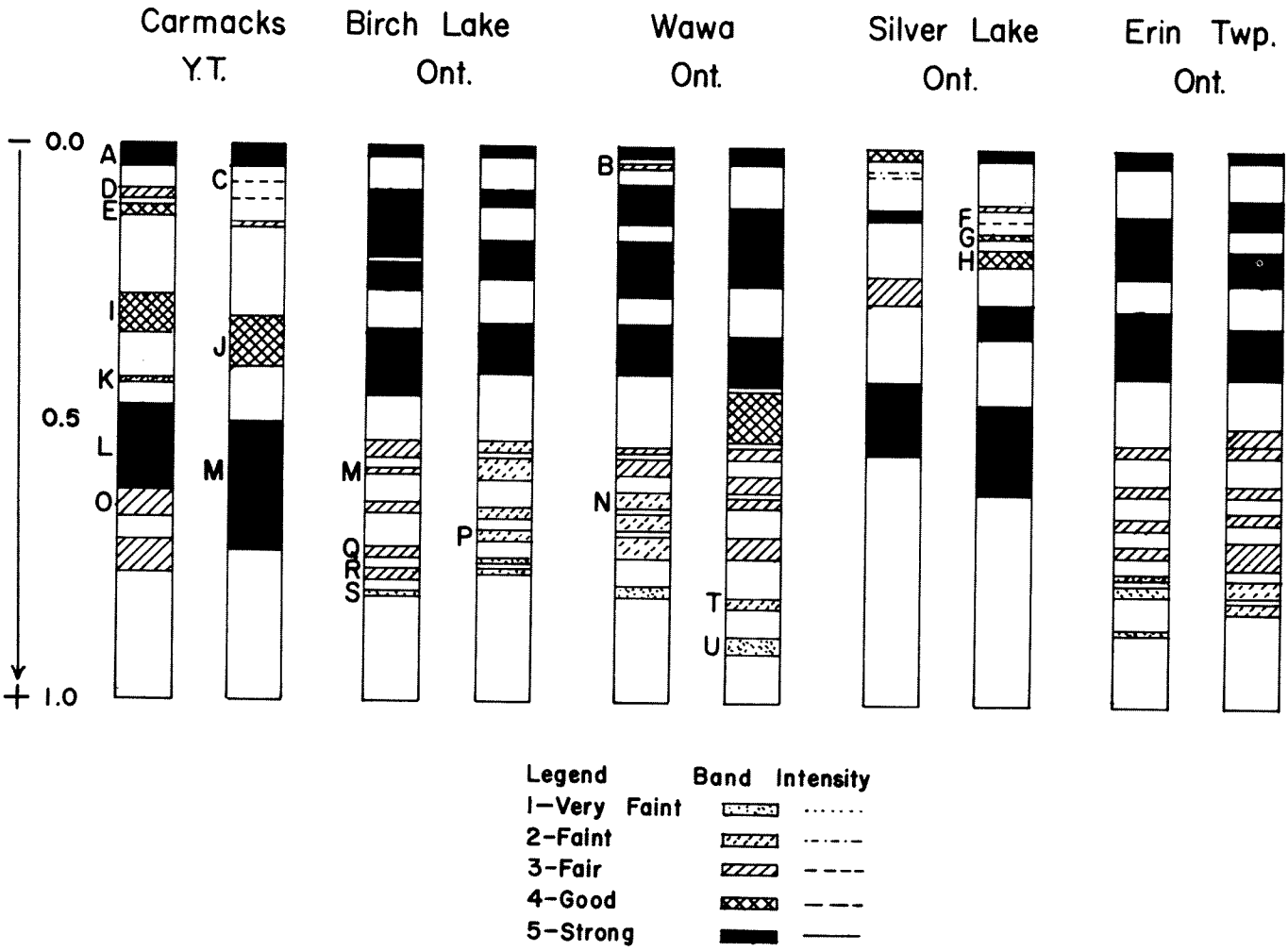

Figure 1. Electrophoretic pattern of proteins in the seeds of *Picea glauca*.

provenances and even progenies of individual trees. In this capacity they serve as useful markers and can be related to the action of individual genes. The potential role of isoenzyme studies for seed certification, analysis of pollen distribution patterns, and seed orchard management has been mentioned in this respect (Rudin, pages 145-164 *in* Proc. IUFRO Jt. Meet., Bordeaux, France, 1976).

Canadian populations across the species range had not previously been investigated, and the first step in the biochemical analysis was therefore the sampling of seed from five locations along a northwest-southeast transect. These locations were Carmacks, Yukon Territory (lat. 62° 03′, long. 136° 14′); Birch Lake, Ont. (lat. 51° 24′, long. 92° 21′); Wawa, Ont. (lat. 47° 55′, long. 84° 45′); Silver Lake, Ont. (lat. 43° 44′, long. 80° 06′); and Erin Township, Ont. (lat. 44° 49′, long. 76° 41′) and there were two trees in each stand.

This exploratory study was primarily undertaken to develop analytic methods and select enzymes useful in subsequent studies based on more samples. One hundred milligrams of dry seeds from each tree were homogenized separately at 4° C, and the crude enzyme was extracted in 0.067M sodium phosphate (pH 7.0) or in 0.2M citrate (pH 7.0) buffer. Isoenzymes were separated by disk electrophoresis on 7.7% polyacrylamide gel at 4° C according to the method of Davis (Ann. N.Y. Acad. Sci. 121:404-442, 1964). The isoenzymes of peroxidase, acid phosphatase, leucine amino peptidase, esterase, and proteins were located on gel matrix by the modified methods (Bhattacharya et al., Biochem. Physiol. Pflanz. 172:439-452, 1978; Smith, Chromatographic and electrophoretic techniques, Interscience Publication, New York, 1968; Bhattacharya et al., Z. Pflanzenphysiol., 1979, in press).

A total of 22 protein bands could be observed as shown in Fig. 1. The number of bands present in any one seed sample ranged from 6 to 11. All the band patterns were different, but the seed samples from the two trees of the same stand showed similar patterns with minor variations. These bands may be classified into three mobility groups: slow (A-E), medium (F-O), and fast (N-P). There are at least two bands with R_F (Resolution Front) 0-.05 and 0.30-0.41 common in all the samples. It is interesting to note that banding patterns in Birch Lake, Wawa, and Erin Township differed in some of the fast migrating protein bands; otherwise slow and medium mobility bands corresponded. However, banding in Silver Lake material is altogether different from that in other regions. A similar situation is also revealed in isoenzyme patterns of peroxidase, acid phosphatase, esterase, and leucine amino peptidase. Of these four, the last three were found to be most useful indicators of regional variation.

From interpretation of the results it would appear that banding patterns of proteins change with regional condition. Perhaps low temperature suppresses the production of new isoenzymes and proteins because of differential gene activity such as is apparent in samples from Carmacks, where temperature during November-January goes down to -12° C unlike the temperatures in other regions (Bernstam, Ann. Rev. Plant Physiol. 29:25-46, 1978).

In summary, it may be noted that protein and isoenzyme patterns change with the location of seed origin. More comprehensive studies are under way to elucidate these patterns in a systematic manner.—N.C. Bhattacharya, NRC Visiting Fellow, Petawawa National Forestry Institute, Chalk River, Ont.

PATHOLOGY

In Vitro Growth of Two Blue Stain Fungi into Resinous Compounds Produced during the Wound Response of Lodgepole Pine.—Lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) responds to infection by *Europhium clavigerum* Robinson and Davidson and *Ceratocystis montia* Rumb. by impregnating tissue surrounding the lesion with resinous substances (Shrimpton, Can. J. Bot. 51:527, 1973). These sapwood-invading fungi have been frequently, but not consistently, isolated from resin-soaked tissues adjacent to mountain pine beetle (*Dendroctonus ponderosae* Hopk.) galleries. They may, however, elicit extractive production by tree tissues and preferentially colonize tissues that accumulate lesser quantities of resin (Reid et al., Can. J. Bot 45:1115, 1967). Volatile and liquid fractions of this resinous accumulation are inhibitory, but not lethal, to the fungi (Shrimpton and Whitney, Can. J. Bot. 46:757, 1968). Resins harden with time, after which they seem to form a physical barrier to fungi (Lyr, Arch. Forstwes. 16:51, 1967). Growth of fungi in the presence of liquid resins is therefore an important aspect of the host-pathogen interaction. We now report an in vitro system that permits visualization of the fungus-resin interaction.

Resin-impregnated sapwood of lodgepole pine surrounding mountain pine beetle galleries was excised, ground, and extracted with acetone. The extract was evaporated to the consistency of thick oil in a rotary evaporator under a water pump vacuum. Detailed procedures, yields and composition of such extracts are given in Shrimpton (1973). Five milliliters of the concentrated extract were aseptically pipetted into each of six sterile 100 mm petri dishes and about 15 mL of melted potato marmite agar (PMA) (Shrimpton and Whitney, 1968) were added to each. The dishes were swirled until the oil extract and agar mixed. The dishes were then allowed to stand and, while the PMA was still liquid, the two phases separated, leaving a film of oil on the surface and extractive-rich zones scattered throughout the hardened medium. The surface film of oil was made discontinuous by the breaking of groups of small bubbles (Fig. 1).

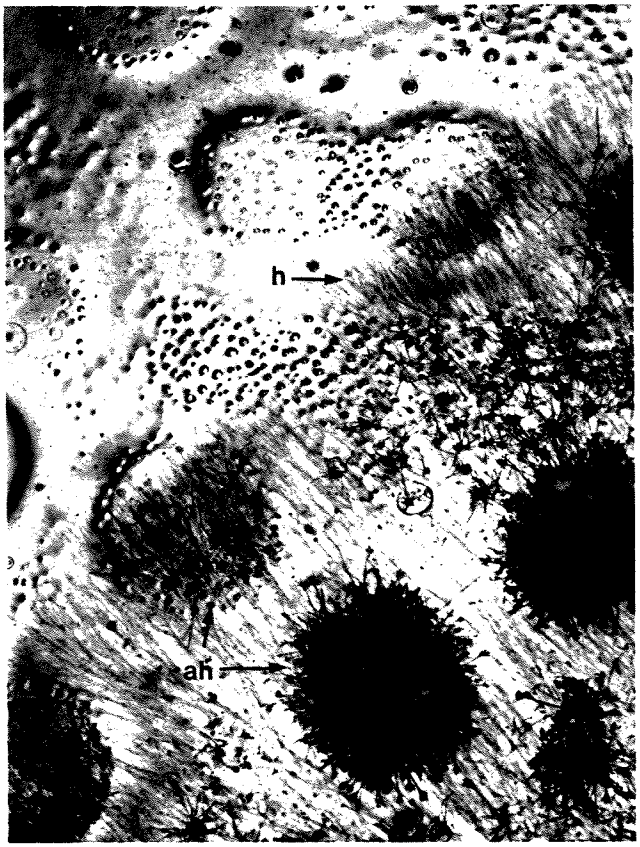

Figure 1. Hyphae (h) of *E. clavigerum* growing beneath the surface oil film and up through the discontinuities in the oil film (ah). x 20.

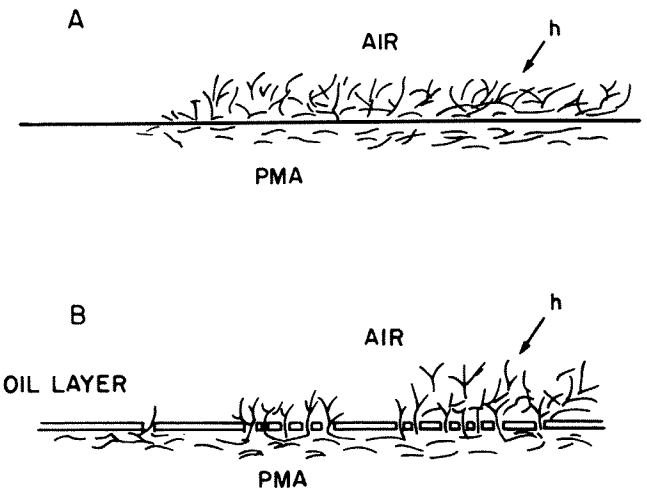

Figure 2. Sectional diagram showing the pattern of advancing hyphal (h) growth. A shows control with no oil and B growth beneath the surface film of oil (PMA — potato marmite agar).

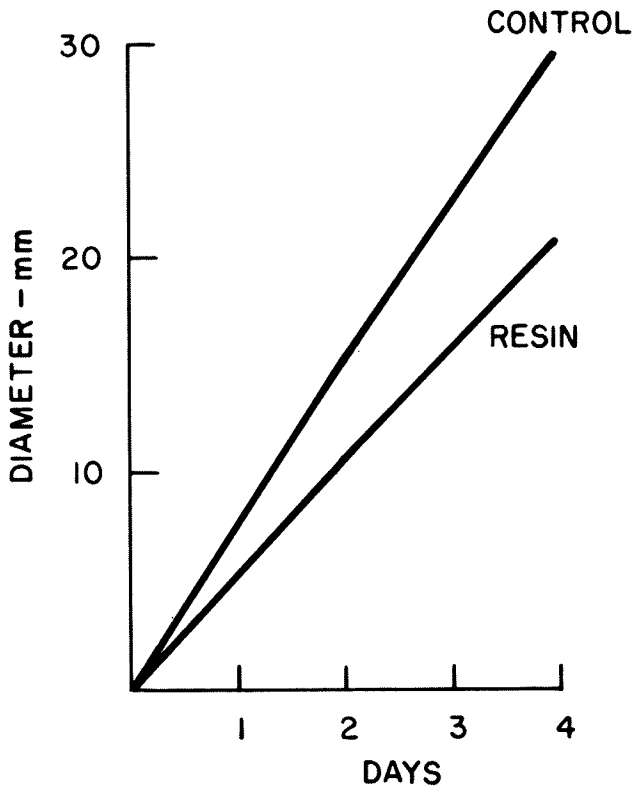

Figure 3. Linear growth of *C. montia* on a medium containing an oily wood extract. The values given are the average for three cultures.

C. montia and *E. clavigerum* were inoculated onto the medium and grown as described previously (Shrimpton and Whitney, 1968). Three cultures of each fungus were grown on PMA containing the oil and three on PMA alone. Cultures were kept at 25° C, examined daily until fully grown, measured 2 and 4 days after inoculation, and photographed after 5 days.

In the absence of oil, both species of fungi grew on the surface of the medium and developed a dense mat of aerial hyphae a few millimeters behind the advancing hyphal tips. On plates containing oil,

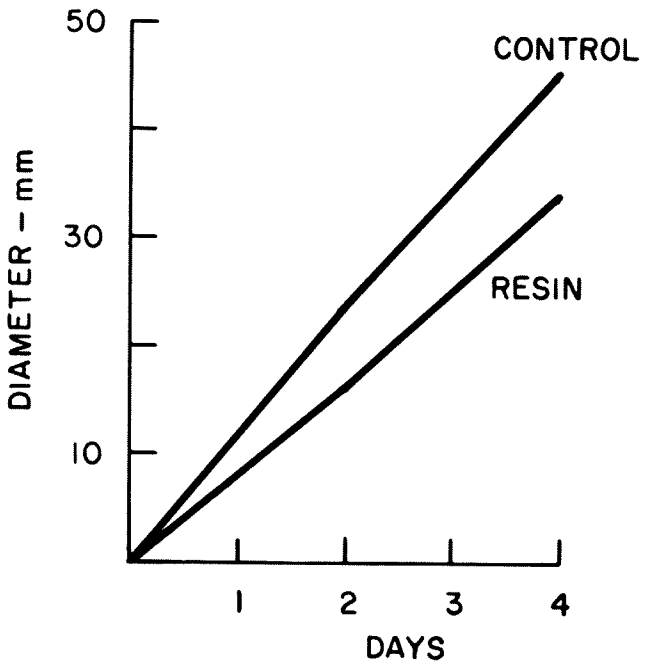

Figure 4. Linear growth of *E. clavigerum* on a medium containing an oily wood extract. The values given are the average for three cultures.

however, the advancing hyphae of both species grew in the medium just beneath the surface film of oil (Figs. 1 and 2) and avoided the embedded zones of oil. About 5-10 mm behind the advancing hyphal front, hyphae grew up through the groups of small holes that broke the otherwise continuous oil layer on the surface. Further behind the hyphal front, hyphae emerging from the small holes gradually developed a dense aerial mat and spread into the oil-containing areas within the medium. Linear growth of *C. montia* is shown in Fig. 3 and of *E. clavigerum* in Fig. 4.

Even though the advancing margin of hyphal growth was in areas of the agar with no apparent oil content, there was an effect from the oil; growth rates were lessened. The advancing hyphae were prevented from growing on the agar surface by the surface film of oil and avoided the oil-rich zones within the medium. However, later growth into the oil-containing areas shows that these oily extractives are not a permanent barrier to hyphal growth. Our observation that oil-rich areas in the medium are colonized after the fungi are in direct contact with the atmosphere suggests that an increase in oxygen is required if hyphae are to grow in contact with the resinous substances produced by lodgepole pine in response to wounding. The growth inhibition, the tendency for hyphae to avoid resins, and the possibly increased requirement for oxygen before growth through oil-containing areas may explain why fungi can be isolated from resin-soaked tree tissues but grow slowly through such tissue.—D.M. Shrimpton and H.S. Whitney, Pacific Forest Research Centre, Victoria, B.C.

A Survey of Ontario Forestry Nurseries for the Presence of *Cylindrocladium floridanum*.—*Cylindrocladium floridanum* Sob. and Seymour, a cause of root rot in forestry nurseries, was found for the first time in Ontario in 1974 (Myren et al., Bi-mon Res. Notes 31:34, 1975). The fungus was isolated from the roots of black spruce (*Picea mariana* [Mill.] B.S.P.) seedlings grown at the Provincial Forest Nursery at Midhurst, Ont. The Forest Insect and Disease Survey Unit of the Great Lakes Forest Research Centre subsequently conducted surveys in a number of forest nurseries in Ontario to determine the distribution of this pathogen.

Soil samples were taken from four nurseries in 1975 and from six in 1976. In the larger nurseries, nine soil samples were collected from each of 15 randomly selected compartments and from up to 14 additional compartments if seedling mortality was present. At small nurseries, all compartments were sampled. The soil was tested for the presence of *C. floridanum* by means of the spot plate technique (Thies and Patton, Phytopathology 56:1116-1117, 1966). The results of the survey are presented in Table 1.

TABLE 1
Compartments yielding *Cylindrocladium floridanum* from soil samples collected at 10 forestry nurseries in Ontario

Nursery location	Compartments sampled (no.)	Compartments yielding *C. floridanum* (%)
Chapleau	6	0
Dryden	17	0
Gogama	5	0
Kemptville	23	13
Longlac[1]	9	0
Midhurst	29	14
Orono	28	4
St. Williams	25	20
Swastika	17	0
Thunder Bay	18	0

[1]Nursery owned by Kimberly-Clark of Canada Ltd.

Cylindrocladium floridanum was found in the four nurseries of southern Ontario — at Kemptville, Midhurst, Orono, and St. Williams — but was not found in any of the six northern nurseries. Although the survey failed to reveal *C. floridanum* in the northern nurseries, it was subsequently isolated from roots of declining black spruce from nurseries at Thunder Bay and Kirkwood (east of Sault Ste. Marie). The latter northern nursery was not included in the general survey. Also, after the survey, *C. floridanum* was found in the Provincial Forest Nursery at Kemptville in a compartment in which it had not been found in the original study. In addition, it was isolated from roots of eastern white pine (*Pinus strobus* L.) and eastern white cedar (*Thuja occidentalis* L.) from the Provincial Forest Nursery at St. Williams.

Thus far, damage caused by this fungus in Ontario forestry nurseries has been fairly light. Results of the special survey indicate that *C. floridanum* is present in southern Ontario nurseries, albeit at fairly low population levels. Failure to detect the fungus in soil samples from the northern nurseries indicated either its absence or a population level too low to detect with the survey technique used.—D.T. Myren, H.L. Gross, and E.B. Dorworth, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

SILVICULTURE

Effect of Seed Weight and Germination Rate on the Initial Growth of Japanese Larch.—Recent interest in the potential of *Larix* species for high yield, short rotation crops has led to trials of various populations of Japanese larch, *Larix leptolepis* (Sieb. and Zucc.) Gordon. In 1978, a field test of seed from 88 sources was initiated at Petawawa National Forestry Institute in cooperation with the Ontario Ministry of Natural Resources. A complementary controlled-environment test revealed wide variation in initial size of seedlings. This report examines the relationship of seed weight and germination rate (time required for germination) to seedling size in the first few weeks of growth.

Twelve seeds of each of the 88 seedlots under investigation were weighed individually, stratified for 32 days at 2°C, and sown in BC/CFS Styroblock 2 containers (one seed per cavity) filled with a 3:1 mixture of peat and vermiculite. The Styroblocks were placed in a greenhouse at 18-25°C and soaked three times daily with Ingestad's nutrient solution (Ingestad, pages 265-269 *in* Proc. XIV IUFRO Congress, München III, 1967). Supplementary fluorescent lighting provided a 16-h photoperiod.

Germination began on the fourth day and was recorded daily for 6 wk. The rate of germination was expressed as days from sowing, and was subsequently used to determine individual seedling age. The population was sampled in two ways: for one sample, a single seedling

TABLE 1
Correlation matrix (86 degrees of freedom) for seedlings 35 days after sowing*

	Seed weight	Germination rate	Seedling weight
Seed weight	1.00	0.17 NS	0.36**
Germination rate	—	1.00	0.81**
Seedling weight	—	—	1.00

* Seedlings in this sample ranged in age from 10 to 31 days from germination.
**Significant at p = 0.01.

TABLE 2
Correlation matrix (86 degree of freedom) for 23-day-old seedlings*

	Seed weight	Germination rate	Seedling weight
Seed weight	1.00	-0.16 NS	0.43**
Germination rate	—	1.00	-0.43**
Seedling weight	—	—	1.00

* Seedlings in this sample germinated from 6 to 16 days after sowing.
**Significant at p = 0.01.

was selected at random from each seedlot 35 days after sowing; another sample consisted of one seedling from each seedlot lifted at random 23 days after it had germinated, thus forming a sample population of uniform age. Seedlings in these two samples were oven-dried (95°C) and weighed individually. The remaining seedlings were planted in a nursery for later study (see last paragraph).

Seed weights among the two samples ranged from 3.7 to 10.9 mg with a population mean of 5.7 mg. Despite this wide range, the correlation coefficient between seed weight and dry weight of seedlings 35 days after sowing was only moderate (r = 0.36, significant at p = 0.01, Table 1).This relationship includes some variation resulting from different ages of seedlings; however, when the influence of age was removed, as in the correlation of seed weight with weight of 23-day-old seedlings (Table 2), the correlation coefficient was only slightly improved (from r = 0.36 to r = 0.43).

A much stronger correlation (r = 0.81) was found between germination rate and dry weight of seedlings 35 days after sowing. The multiple correlation coefficient between seedling weight and germination rate and seed weight combined was 0.84.

The results agree with those of Ackerman and Gorman (Pulp Pap. Mag. Can. 70:167-169, 1969), who found that only a small part of the initial variation in seedling size of white spruce, *Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg., and lodgepole pine, *Pinus contorta* Dougl. var. *latifolia* Engelm., could be accounted for by seed size. They also suggested that rate of germination and genetic factors were possible sources of variation.

The experiment also provided information about germination vigor. The weight of 23-day-old seedlings was negatively correlated with the date of germination (r = -0.43, Table 2). In other words, seeds germinating early produced larger 23-day-old seedlings than those germinating later. Since the rate of germination is indicative of germination-vigor classes, it is suggested that in Japanese larch the vigor of initial seedling growth is related to germination vigor.

Lack of uniformity in the size of stock creates problems in nursery management, whether seedlings are grown in nursery beds or in containers. The results reported here show that, although seed weight has some effect on initial size of Japanese larch seedlings, most of the variation can be accounted for by differences in the rate of germination. Since a principal goal of nursery operations is to produce a uniform crop of seedlings in a short period, treatments favoring early germination will be advantageous in Japanese larch. Whether the influences of seed weight and germination rate extend beyond the first growing season will be the subject of further study with the 880 seedlings remaining from this experiment.—K.T. Logan, Petawawa National Forestry Institute, Chalk River, Ont., and D.F.W. Pollard, Pacific Forest Research Centre, Victoria, B.C.

ENTOMOLOGY

Possible Use of Canopy Light Traps in Predicting Spruce Budworm Egg-mass Counts.—Light traps, illuminated with naptha-fuel lamps and located in forest clearings, have been used for many years in the Maritime Provinces to monitor changes in the abundance of spruce budworm moths at selected locations. In recent years, this monitoring program has been expanded by the use of light traps suspended within the crown canopy to obtain an index of budworm-moth abundance in infested stands. The data were used to compare moth counts in adulticide-treated stands with counts in untreated areas, and to find the relationship between moth abundance (females) and egg-mass counts. The latter project is the topic of this note.

TABLE 1
Counts of spruce budworm pupae, egg masses, and females per canopy light trap and calculated ratios.

Year	Area	Counts/10 m² foliage: Female pupae (1)	Counts/10 m² foliage: Egg masses (2)	Total females in light trap (3)	Ratios: Light-trap females (3) / Female pupae (1)	Ratios: Egg masses (2) / Light-trap females (3)
1974	C	86	668	7,339	85	0.09
1975	C	100	804	10,315	103	0.08
1975	J	27	338	8,500	315	0.04
1976	A	91	380	2,158	24	0.18
1978	ANS	87	245	1,197	14	0.20
1978	Q	27	160	1,158	43	0.14

TABLE 2
Comparison of observed and expected egg-mass densities in 10 plots based on Fig. 1

Plot	Female pupae/10 m² (1)	Total light-trap females (2)	Ratio (2)/(1)	Expected egg masses/light-trap female (Fig. 1)	Egg masses/10 m²: Expected	Egg masses/10 m²: Actual
1	27	297	11	0.23	68	93
2	71	177	2	0.40*	71	65
3	33	339	10	0.25	85	114
4	9	329	37	0.13	43	53
5	4	1,083	271	0.04	43	25
6	1.3	878	675	0.025	22	23
7	1.3	1,357	1,043	0.020	27	20
8	0	592	(592)	(0.025)	(15)	4
9	0	818	(818)	(0.021)	(17)	7
10	0	No data				9

*Extrapolation of Fig. 1.
( ) A female density of 1.0/10m² being assumed, although no pupae were found on plots 8, 9, and 10,in a sample of 36 midcrown branches per plot.

TABLE 3
The number of light-trap females that will likely result in severe defoliation relative to female pupal density

	Female pupal density/10 m² foliage: 10	20	40	60	80	150
Maximum acceptable count of females in light trap	10,000	6,000	2,500	1,500	1,100	750

Observations were made in five study areas over 4 yr. Populations were estimated from three different samples taken in each area — pupae plus pupal cases, egg masses, and budworm moths captured during a season (20±3 days) in one light trap suspended within the crown canopy (Table 1). Pupae and egg masses were counted on one midcrown branch per tree on a maximum of 10 trees per location. This small sample size resulted in high intraplot variation.

No relationship was found between the number of female moths taken in a light trap and pupal counts (converted to number of females)

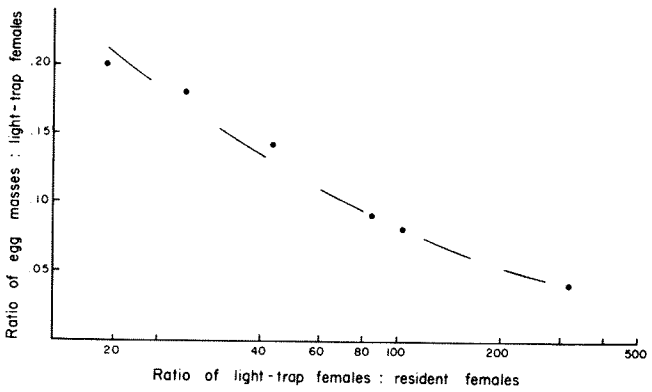

Figure 1. Graphic relationship of apparent oviposition per trapped female to the ratio light-trap females:resident females.

because moth invasion and emigration can profoundly affect local population densities. Similarly, in a graphic analysis of egg-mass counts, a scattered relationship was found between the number of egg masses and the number of female pupae, again because dispersing females can add to, or subtract from, the expected oviposition by a local population. However, an improved relationship was noted when egg-mass counts were plotted over the number of females captured in a light trap. Further improvement was obtained when the ratio of egg masses:light-trap females was plotted over the ratio of light-trap females:resident females (Fig. 1). Although Fig. 1 provides little biological information and ratios must be treated with caution, it suggests that apparent oviposition per trapped female is at a maximum when females are mainly of "local origin" and decreases when the local population is diluted by invaders. This may be because dispersing females, on the average, carry 50% or less of their egg complement.

The sensitivity of Fig. 1 is open to question and we had only one set of independent data (collected by another research group in 1977 in northwestern New Brunswick) for validation (Table 2). Although budworm densities were low in these plots (Table 1), the expected egg-mass counts based on Fig. 1 were within broad limits of the observed counts (Table 2). In view of this, we suggest one possible use of this survey technique: Assuming that larvae from 240 egg masses per $10m^2$ of foliage will cause severe defoliation of balsam fir (greater than 66% loss of current needles), it is possible to calculate (from Fig. 1) the number of light-trap females that would produce 240 masses, given a range of female pupal densities (Table 3). Thus the risk of severe defoliation in a stand may be predictable from the observed catch of females in a canopy light trap. The merit in the system is that, while egg-mass sampling is labor-intensive, counting pupae and tending a light trap require fewer resources.

Light traps capture female moths that have laid most of their eggs (A.W. Thomas, Maritimes Forest Research Centre, pers. commun.) and many other factors (trap location, quality of light, temperature, humidity, level of natural light) can affect the size of a nightly catch. Furthermore, we speculate that a relationship would not exist between the number of light-trap females and the number of egg masses in heavily attacked stands (some dead trees and more than 50% total needle loss among surviving trees), where moth emigration would probably be at a maximum and the site would be unfavorable for invaders. However, Fig. 1 suggests that two population counts — total females in a canopy light trap and resident pupal density — could be used to broadly predict the number of egg masses in moderately infested stands. Additional testing will be conducted in 1979.—C.A. Miller, D.O. Greenbank, and E.G. Kettela, Maritimes Forest Research Centre, Fredericton, N.B.

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